PATENT SPECIFICATION

599,018

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COMPLETE SPECIFICATION

Improvements in or relating to Voltage Control in Rectifying Arrangements

We, STANDARD TELEPHONES AND CABLES LIMITED, a British Company, EDWARD ARTHUR RICHARDS and WILLIAM EDWARD PEASE, both British Subjects, all of Connaught House, 63, Aldwych, London, W.C.2, England, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

The present invention relates to arrangements for rectifying electric alternating current, and is concerned with the regulation of the output rectified voltage.

It is frequently a requirement for a rectifier circuit that the rectified output voltage should be substantially independent of variations in the output load, and/or of variations in the alternating voltage of the source which energises the rectifier.

A well known method of compensating for such variations is to control the alternating voltage supplied to the rectifier by connecting a saturable choke coil in series with the supply source, and to vary the inductance of the choke by means of a direct current derived from the output of the rectifier, which current is passed through an auxiliary winding of the choke. For example, it is well known to pass the output load current through the auxiliary winding and to arrange that an increase in the load current causes a decrease in the choke impedance. This produces an increase in the alternating voltage applied to the rectifier, which offsets the fall in rectified output voltage which would otherwise result.

Although this arrangement is simple it has certain disadvantages, the most important of which is that it tends to accentuate the effects of variations in the alternating voltage of the source. It also proves to be difficult to design such a circuit so that it has a flat regulation characteristic over the working range of the rectifier.

For these reasons, rectifier circuits have been proposed in which a variable resistance is associated with the direct current winding of the saturable choke, the resistance being automatically controlled from the output side of the rectifier in such manner as to vary the impedance of the choke in the desired manner to obtain a constant rectified voltage. One such arrangement is described in British Patent Specification No. 510,730, in which in a three-phase rectifier, in addition to the usual saturable series chokes through which the load current passes, there is provided a set of saturable chokes arranged in shunt with the input circuit, the saturating current in the shunt chokes being derived from the rectified output voltage through a variable resistance (preferably of the carbon pile type) also controlled by the output voltage. This is a very complicated arrangement, and another much simpler circuit of this class is described in the specification of co-pending application No. 22477/45 (Serial No. 598,206). In this case the auxiliary winding of the series choke is connected in series with a direct current source derived independently of the rectifiers or load current and in series with the variable resistance, which is preferably a carbon pile resistance controlled in accordance with the output rectified voltage of the rectifiers. The circuit also may include an anti-hunting arrangement.

The fact that a separate source is used for saturating the choke means that there will be a loss of efficiency. The arrangement of the present invention, while generally similar to this arrangement, avoids this loss of efficiency by employing the load current, either directly or indirectly, to saturate the choke coil, a carbon pile or other variable resistance controlled by the output rectified voltage being also employed as an auxiliary control.

The invention accordingly provides an electric rectifying arrangement for supplying direct current to a variable load from a source of variable alternating voltage comprising a rectifier, a saturable

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choke coil having a winding connected in series between the source and the rectifier, means for applying a proportion of the output load current either directly or indirectly to control the impedance of the choke coil, means including a variable resistance for controlling the said proportion and means for automatically varying the said resistance in such manner as to maintain the rectified output voltage substantially constant.

The invention will be described with reference to the accompanying drawing in which Figures 1 and 2 show schematic circuit diagrams of two embodiments thereof.

Referring to Figure 1, a source of single phase alternating voltage (not shown) is intended to be connected to the input terminals 1 and 2. The output terminals at which the rectified voltage is developed, and to which the load (also not shown) is intended to be connected are 3 and 4. The terminals 1, 2 are connected through a transformer 5 of appropriate ratio to one pair of diagonal terminals of a bridge rectifier 6, the other pair of diagonal terminals of which are connected to the output terminals 3 and 4. Connected in series with the primary winding of the transformer 5 is the principal winding 7 of a saturable choke coil 8 preferably of the type having a three-limbed core. The auxiliary winding 9 of this choke coil is connected in series between one output terminal 4 and the corresponding corner of the bridge rectifier 6.

This auxiliary winding has associated therewith a regulator 10 consisting of a resistance 11 which is connected in shunt with the auxiliary winding 9. The value of the resistance 11 is controlled by a winding 12 connected in series with an adjustable resistance 13 across the output terminals 3 and 4. The regulator 10 should be arranged so that an increase in the current through the controlling winding 12 produces a decrease of the value of the resistance 11. Adjustment of the resistance 13 enables the regulator to be set so that the rectified output voltage is maintained substantially at a desired value.

If the rectified output voltage should tend to increase above the desired value, either because of a decrease in the load, or of an increase in the alternating voltage of the source, the effect will be to decrease the resistance 11 and therefore to decrease the proportion of the load current which flows through the auxiliary winding 9 of the choke 8. This causes an increase in its impedance and therefore a decrease in the voltage applied to the rectifier 6 which therefore offsets the tendency of the output rectified voltage to increase. The opposite action would occur should the output rectified voltage tend to decrease.

In the arrangement of Figure 1, the resistance 11 carries a comparatively small proportion of the load current. The major portion flows through the auxiliary winding 9 and controls the inductance of the choke coil 8 so as to compensate in the well known manner for the major portion of the rectified voltage variations which are due to the variation in the load. The main function of the regulator 10 is to compensate for the variations of the input alternating voltage which are beyond the scope of the ordinary arrangement. The regulator 10 also improves the action of the circuit even when the input alternating voltage is constant so that better regulation over a wider range becomes possible.

The embodiment shown in Figure 2 differs from that of Figure 1 in that the winding 9 of the choke coil is energised by means of a second bridge rectifier 14 connected in series between the supply source and the transformer 5. As before, the resistance 11 is connected in shunt with the auxiliary winding 9, the control winding being connected in the same way as in Figure 1.

The action of the circuit of Figure 2 is substantially the same as that of Figure 1, but the auxiliary winding 9 of the choke coil is energised indirectly by the load current. It will be appreciated that the winding 9 is placed effectively in series with the primary windings of the transformer 5 by the action of the bridge rectifier 14 so that the rectified current which flows therethrough will be practically proportional to the load current. In other words, the auxiliary winding is effectively energised by the load current on the input side of the transformer 5 instead of on the output side, and this arrangement has the advantage that it can be adapted to supply a wide range of load currents without the necessity of using a different choke coil for each value of load current, the only modification required being suitable adjustment of the ratio of the transformer 5. It is pointed out that in the arrangement of the specification last referred to, i.e., No. 22477/45 (Serial No. 598,206), the auxiliary winding of the choke coil is energised from the alternating current source in parallel with the load transformer, and so is not affected either directly or indirectly by the rectified load current.

Another advantage of the arrangement

of Figure 2 over that of Figure 1 is that since the saturating current of the choke 8 includes the magnetising current of the transformer 5 and also the reverse leakage current of the rectifier I4, better regulation of the output load current is obtained for small load currents.

One of the advantages of both these circuits is that the power handled by the regulator is only a small fraction of the total power delivered to the load. This enables the regulator to be of small dimensions. An obvious alternative, of course, is to reverse the action of the regulator and to put it in series with the load and the saturating winding, but in this case, the regulator must handle the whole of the load current and be correspondingly larger. A preferred form of the regulator in the embodiment described is a small carbon pile type in which the resistance of a pile of carbon discs is controlled by the pressure of an electromagnet of which the winding corresponds to the winding 12 of Figures 1 and 2. Another form of regulator would be an indirectly heated thermistor of suitable dimensions, having a negative temperature co-efficient of resistance, of which the resistance element corresponds to 11 and the heating coil to 12 in Figures 1 and 2. Either type of regulator may be provided with known means for compensating for temperature and for preventing hunting of the control if desired.

It will be understood that arrangements similar to Figures 1 and 2 may be made for multiphase circuits. Usually a separate choke such as 8 will be used in series with each of the phase conductors and the auxiliary windings will all be connected in series. In a balanced circuit the voltage induced in the auxiliary windings will be cancelled out.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. An electric rectifying arrangement for supplying direct current to a variable load from a source of variable alternating voltage, comprising a rectifier, a saturable choke coil having a winding connected in series between the source and the rectifier, means for applying a proportion of the output load current either directly or indirectly to control the impedance of the choke coil, means including a variable resistance for controlling the said proportion, and means for automatically varying the said resistance in such manner as to maintain the rectified output voltage substantially constant.

2. An electric rectifying arrangement for supplying direct current to a variable load from a source of variable alternating voltage, comprising a rectifier, a saturable choke coil having a principal winding connected in series between the source and the rectifier, means for supplying direct current derived from the load current to an auxiliary winding of the choke coil for controlling the impedance thereof, a variable resistance connected in series or in parallel with the auxiliary winding, and means for applying the rectified output voltage to control the said variable resistance in such manner as to maintain the said rectified output voltage substantially constant.

3. An arrangement according to claim 2 in which the said rectifier is a bridge rectifier having one pair of diagonal terminals connected to the said source in series with the said principal winding.

4. An arrangement according to claim 3, in which the other pair of diagonal terminals of the said rectifier are connected to the said load in series with the said auxiliary winding, the said auxiliary winding being shunted by the said variable resistance.

5. An arrangement according to claim 3 in which the other pair of diagonal terminals of the rectifier are connected directly to the load, and in which the said auxiliary winding, is energised in parallel with the said variable resistance from a direct current source separate from the said rectifier.

6. An arrangement according to claim 5, in which the said direct current source comprises a second bridge rectifier energised from the said source of variable alternating voltage.

7. An arrangement according to any of the claims 2 to 6 in which the value of the said resistance is controlled by means connected to the terminals of the said load.

8. An arrangement according to claim 7, in which the said means comprises a controlling winding connected in series with an adjustable resistance.

9. An arrangement according to claim 7 or 8 in which the said variable resistances is a carbon pile resistance having the controlling winding connected to the terminals of said load.

10. An arrangement according to claim 7 or 8 in which the said variable resistance is the resistance element of a thermistor having a negative temperature co-efficient of resistance, the heating coil of which is connected to the terminals of the said load.

11. An arrangement according to any

of the claims 2 to 10 provided with known means for preventing hunting in the regulation of the output rectified voltage.

12. The electric rectifying arrangement described with reference to Figure 1 or to Figure 2 of the accompanying drawing.

Dated this 18th day of May, A.D. 1945.

ERNEST E. TOWLER,
Chartered Patent Agent,
For the Applicants.

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[This Drawing is a reproduction of the Original on a reduced scale.]

FIG. 1.

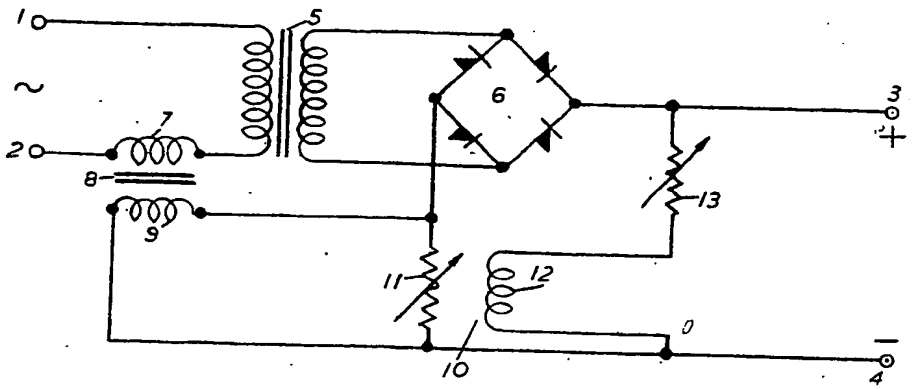
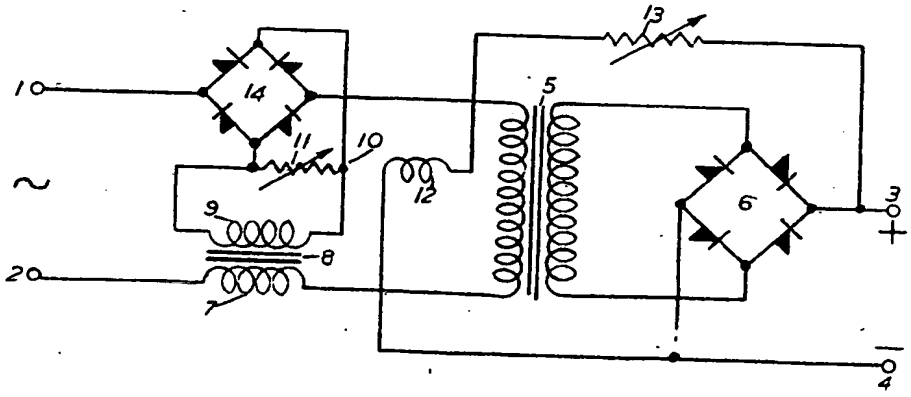


FIG. 2.



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